Patent Application of

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for

TITLE OF THE INVENTION: A NON-INCENDIARY DIRECTIONALLY ILLUMINATED TRACER BULLET

CROSS-REFERENCE TO RELATED APPLICATIONS: Not Applicable

FEDERALLY SPONSORED RESEARCH: Not Applicable

SEQUENCE LISTING OR PROGRAM: Not Applicable

BACKGROUND OF THE INVENTION

001 The present invention relates to ballistic ammunition, and is based on technologies envisioned in Provisional Patent Application 60/423,441, filed November 01, 2002. Specifically, it relates to tracer bullets that are non-pyrotechnic and fire-safe, by recessing a rearward shining directional light source along with an electric power supply and switch into the base of an otherwise standard bullet to illuminate the ballistic trajectory to the shooter without revealing the trajectory to hostile observers.

BACKGROUND — DESCRIPTION OF PRIOR ART

002 Current approaches to illuminating the ballistic path of a tracer bullet commonly rely on igniting pyrotechnic agents that are housed in the hollow base of the bullet, as is taught, for example, by DePhillipo , et al., United States Patent 4,528,911. While this situation facilitates judging effectiveness of a particular shooter in terms of hitting a particular target with a particular tracer bullet, the use of pyrotechnic agents creates three concerns. Concern #1: light emitted from combustion of the pyrotechnic agent is visible from many viewing angles because photons are scattered by particles in the smoke trail from combustion of the pyrotechnic agent that is distributed behind the bullet; this serves to indicate the location of the shooter to hostile observers. Concern #2: combustion of the pyrotechnic agent reduces the mass of the bullet while on the way to the target, causing the trajectory of the tracer bullet to differ from that of "normal" (nontracer) bullets whose mass is unchanged on the way to the target. That is, when used in automatic weapons, the bullet "stream" is commonly composed of tracer and nontracer bullets. If the tracer bullets follow a trajectory that differs from that of the nontracer bullets, then the effectiveness of the tracer bullets does not correspond to the effectiveness of the nontracer bullets. Thus, even if Concern #1 could be relieved by using pyrotechnic agents that when burned, emit light primarily in wavelengths invisible to the unaided human eye, (as is taught, for example, by Nielson, United States Patent 5,639,984), Concern #2 remains because the tracer bullet mass changes on the way to the target. Concern #3: combustion of the pyrotechnic agents creates a significant fire hazard when such ammunition is expended in the vicinity of combustible material such as would occur in vegetated areas (woods, grass, etc.), requiring

exceptional precautions to prevent fires. Indeed, military training posts maintain special fire prevention and safety programs to meet this need (see, for example, U.S. Department of the Army, November 28, 1997; Pamphlet 385-64, *Ammunition and Explosives Safety Standards*, Headquarters, Department of the Army, Washington, DC). Furthermore, the use of such tracer ammunition at civilian shooting ranges is expressly prohibited by local ordinance in many jurisdictions.

BRIEF SUMMARY OF THE INVENTION

003 The present invention is a non-incendiary directionally illuminated tracer bullet characterized by having a shock resistant rearward shining electrically powered directional light source, such as a light emitting diode, a laser diode or a related light source, and a shock resistant power source and switch for said directional light source. The rearward shining directional light source emits visible light or infrared light or ultraviolet light. One power source for the rearward shining directional light source can be comprised of one or more electrochemical cells, said one or more electrochemical cells being activated by wetting the electrodes with an electrolyte. The wetting process is initiated by acceleration induced rupture of an electrolyte containing ampoule, said acceleration deriving from firing the ammunition cartridge. Subsequent centrifugal acceleration deriving from axial spin imparted to the bullet by passage through a rifled gun barrel distributes the electrolyte to wet the electrodes, thus powering the rearward shining electrically powered directional light source. Another electrical power source is comprised of piezoelectric material and a capacitor. The piezoelectric material produces an electric charge when it is deformed when the non-incendiary tracer bullet is deformed by passage through a rifled gun

barrel. Said electric charge is stored in a capacitor for subsequent discharge to the rearward shining directional light source.

BRIEF DESCRIPTION OF THE DRAWINGS

004 FIGURE 1 is a cross-sectional view of the preferred embodiment. FIGURE 2 is a schematic view of the preferred embodiment of the electrical power supply and switch. FIGURE 3 is an alternative embodiment of the electrical power supply and switch. Another embodiment for the electrical power supply and switch that uses compression of piezoelectric material to produce an electric charge stores said electric charge in a capacitor for subsequent discharge to the rearward shining, directional light source.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

005 The present invention is based on technologies envisioned in Provisional Patent Application 60/423,441,filed November 01, 2002, and it seeks to alleviate all three concerns referenced above. The above-referenced Concern #1 (illumination of the shooter) is alleviated by mounting a rearward shining shock resistant and electrically powered directional light source, power supply, and switch in a cavity formed in the hollow base of the bullet. An acceleration-activated switch connects the electric power supply to the rearward shining shock resistant and electrically powered directional light source upon firing the bullet. In flight, axial spin of the bullet (as imparted by rifling grooves machined into the inner surfaces of the gun barrel) keeps the rearward shining shock resistant and electrically powered directional light source pointed at the shooter, and thus away from the target. When emission characteristics of the rearward shining shock resistant and

electrically powered directional light source are selected to minimize sidescatter under prevailing atmospheric conditions, the luminous spot associated with the bullet's trajectory is visible primarily to the shooter. Light-emitting diodes (LEDs) and laser diodes exist to satisfy requirements for the rearward shining shock resistant and electrically powered directional light source, and such light sources are optimized to deliver optical emissions in the ultraviolet, visible, and near-infrared bands (see, for example, Bergh, A., G. Craford, A. Duggal, and R. Haitz, 2001; "The Promise and Challenge of Solid-State Lighting"; *Physics Today*, Volume 54, No. 12, pp. 42-47; and see OIDA, 2001; *The Promise Of Solid State Lighting For General Illumination Light Emitting Diodes [LEDs] And Organic Light Emitting Diodes* [OLEDS]. Optoelectronics Industry Development Association, Washington, DC; http://www.OIDA.org). This provides the means to assign specific wavelengths coordinated to need. Such needs include definition of specific colors (i.e., blue, green, or red) to distinguish friend from foe, and definition of wavelengths that are invisible to the unaided human eye (ultraviolet and near-infrared).

006 The present invention alleviates the above-mentioned Concern #2 (in-flight mass changes of the tracer bullet) by establishing a tracer illumination system that does not consume material. Minor differences between the fixed mass of the tracer bullet embodied in the present invention and the fixed mass of the otherwise standard bullet can be accomodated by adjusting the propellant charge in the ammunition cartridge, or by adjusting the mass of the tracer bullet, or both, to achieve equivalent trajectories.

007 The present invention alleviates the above-referenced Concern #3 (fire hazard) by using electronic illumination. In addition to providing precise control over emitted wavelengths,

directionality, and brightness, this also reduces the prospects for igniting combustible material struck by the bullet. Thus the fire hazard associated with use of the present invention is no worse than that associated with traditional (nontracer) ammunition.

008 Referring now to FIGURE 1, the preferred embodiment of the ammunition cartridge **1**, according to the present invention, comprises a rearward shining shock resistant and electrically powered directional light source **2**, an electrical power supply **3** and a switch **4**, all of which are disposed within a cavity **5** formed within the base portion **6** of the non-incendiary directionally illuminated tracer bullet **7**. Excepting the cavity to hold the light source **2**, power supply **3**, and switch **4**, the directionally illuminated tracer bullet **7** is formed by the otherwise standard bullet. The directionally illuminated tracer bullet **7** is launched by igniting the propellant charge **8** housed in the otherwise standard ammunition casing **9**. Rapid acceleration of the directionally illuminated tracer bullet **7** associated with firing the propellant charge **8** activates the switch **4**, transferring electrical power from the power source **3** to the rearward shining shock resistant and electrically powered directional light source **2**. An inert pad **10** protects the rearward shining shock resistant and electrically powered directional light source 2 from blast effects, and a spring **11** ejects the pad from the rear face 12 of the rearward shining shock resistant and electrically powered directional light source **2** upon firing the ammunition cartridge **1**.

009 Passage of the bullet **7** through a rifled gun barrel imparts axial spin on the bullet **7**, stabilizing the in-flight trajectory. This spin-stabilization also serves to orient the base portion **6** of the directionally illuminated tracer bullet **7**, and thus orienting the emitting face of the rearward shining

shock resistant and electrically powered directional light source **2** towards the shooter, facilitating visual tracking of the trajectory by the shooter and/or friendly observers stationed along favorable sightlines. That is, as the bullet approaches the target, the luminous trail created by the rearward shining shock resistant and electrically powered directional light source is visible primarily along a sightline leading back to the shooter.

010 In the simplest embodiment of the invention, the switch **4** permanently and instantaneously connects the rearward shining shock resistant and electrically powered directional light source **2** to the electrical power supply **3** upon firing of the cartridge **1**. This causes the rearward shining shock resistant and electrically powered directional light source **2** to be illuminated at the earliest moment in its duty cycle. The inventors conceive a second embodiment in which a delay factor of about a few milliseconds delays illuminating the rearward shining shock resistant and electrically powered directional light source **2** until the bullet **7** has reached a preferred distance downrange that would not create visual interference for the shooter, so that the brilliance of the rearward shining shock resistant and electrically powered directional light source won't temporarily blind or otherwise overwhelm the shooter, particularly under dimly lit and nighttime conditions. At a muzzle velocity of 1,000 feet per second, for example, a delay factor of 10 milliseconds corresponds to a down range delay distance of about about 100 feet.

011 In a third embodiment, the brightness of the rearward shining shock resistant and electrically powered directional light source **2** would be controlled over time so that the radiated light is dimmest near the muzzle and brightest downrange. The inventors conceive that such control of the brightness can be

brought about by the design of the switch **4** or of the power supply **3**, or both.

012 In each of the above-described embodiments, the electrical power supply **3** may employ any electrochemical system or battery that provides sufficient electrical current to illuminate the rearward shining shock resistant and electrically powered directional light source 2 for the desired time period. Such an electrochemical system or battery must, however, meet shelf-life requirements that apply to otherwise standard ammunition (see, for example, U.S. Department of the Army, November 28, 1997; Pamphlet 385-64, Ammunition and Explosives Safety Standards, Headquarters, Department of the Army, Washington, DC).

013 Referring now to FIGURE 2, the preferred embodiment of the electrical power supply and switch, according to the present invention, is comprised of an ampoule filled with electrolyte **13**, that in readiness for firing the ammunition cartridge, sits inside a symmetric cavity **14** in the directionally illuminated tracer bullet **7** whose inner surface is lined with alternating anode material **15** and cathode material **16**, the anodes and cathodes being connected together to form one or more electrochemical cells so that when the ammunition cartridge is fired, initial acceleration ruptures the electrolyte-filled ampoule **13**, and centrifugal forces associated with the axial spin imparted by passage of the bullet over grooves cut into the rifled gun barrel quickly distribute the electrolyte between the anode material **15** and cathode material **16** to form a battery. A chemically inert lining **17** isolates the battery system from the metal body of the directionally illuminated tracer bullet **7** and prevents internal short circuiting. One example of such a battery would use sulfuric acid as the electrolyte, lead as the cathode, and lead dioxide as the anode, providing approximately 2 volts per cell. Given that the duty cycle of the directionally

illuminated tracer bullet is a few seconds, and that the directionally illuminated tracer bullet is not subject to reuse, the amount of electrolyte can be minimized to reduce concerns associated with unwanted corrosion should the ampoule of electrolyte be inadvertently ruptured without firing the ammunition cartridge.

014 Referring now to FIGURE 3, another embodiment for the power supply and switch can be realized using compression of piezoelectric material to produce an electric charge. The cavity housing the piezoelectric material 18 provides for a snug fit against the bullet cavity **19** so that when the bullet **7** passes through the rifled gun barrel, compressive forces associated with passage over the rifling grooves are transferred to the piezoelectric material 18. The electric charge produced by compression of the piezoelectric material is stored in a capacitor for subsequent discharge to the rearward shining, directional light source. The time delays associated with generating and storing the charge can be further controlled, as needed, by specific circuitry to achieve desired delays and brightness changes and coded (blinking) effects.